BELLCOMM, INC.

SUBJECT: Technical Development of Toroid Bi-propellant Containers - Discussions With H. Wuenscher, Director, Manufacturing Engineering Laboratory, MSFC - Case 103-2

DATE: March 3, 1967

FROM: D. Macchia
M. H. Skeer

ABSTRACT

This memorandum briefly reviews the present direction of the toroidal tank development program at MSFC. Here particular emphasis is currently being placed on large tank systems (on the order of 200 inches) for cryogenic propellant containers.

The authors see various applications for a smaller class of toroidal tankage and suggest that a comprehensive fabrication program be undertaken to cover both large and small classes of toroidal containers. Concurrent investigations of related problems such as propellant compatibility, material selection, expulsion techniques, stress analysis, and slosh effects should be incorporated to compliment a manufacturing methods study.

Mr. Wuenscher of MSFC was of the opinion that if general future probe design applications and specific project needs (as the toroidal propellant container system for the MSSR) justify a small tank fabrication and test development program, such a program would effectively compliment the large toroidal cryogenic tank program presently being undertaken.

While such a toroidal tank development program is clearly worthwhile, it is the authors' belief that cryogenic tankage development and fabrication is a higher priority problem and should not be compromised if this was deemed necessary to accomodate both programs.

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BELLCOMM, INC.

SUBJECT: Technical Development of Toroidal Bi-propellant Containers - Discussions With H. Wuenscher, Director, Manufacturing Engineering Laboratory, MSFC - Case 103-2

DATE: March 2, 1967

FROM: D. Macchia
M. H. Skeer

MEMORANDUM FOR FILE

The authors visited the Manufacturing Engineering Laboratory, MSFC for technical discussions with H. Wuenscher concerning recent structures development programs at MSFC. Of special interest was the large toroidal tank fabrication and test program presently under the direction of Mr. Wuenscher which is being funded out of OART.

The principal application of the large toroidal tanks (on the order of 200 inches) being studied at MSFC is for cryogenic propellant containers. The squat configuration of the toroid is particularly suited for packaging the cryogenic stage oxidizer propellant. For the fuel/volume ratio of many propellant combinations, the toroidal oxidizer tank can be efficiently nested under the much larger spherical or elliptical domed fuel tank, thus providing a short, densely package propulsion module or booster stage.

A second application for the toroid shell configuration is a semi-toroidal propellant container which offers a substantial packaging advantage over conventional spherical or ellipsoidal domed tanks. The semi-toroidal tank is essentially a cylinder with toroidal caps and a center column which forms a natural path for routing a feed lines.

Applications for smaller toroidal tank counterparts (from 30-60 inch diameter) can also be conceived for various spacecraft designs. For example, in a design study of a Mars Surface Sample Return vehicle (MSSR) by the authors (Ref. 1) toroidal bi-propellant containers with dual positive expulsion diaphragms were suggested as a possible tank configuration (Fig. 1). This configuration is especially suited to MSSR requirements because of the low structural fraction achieved under a broad spectrum of design loads and packaging constraints.

[redacted]

The principal problem of assessing the feasibility and desireability of the MSSR toroidal tank design appears to be in the fabrication of the toroidal tankage with the dual diaphragm expulsion devices. Heretofore, no design test specimens of toroidal tanks employing positive expulsion have been built; nor has sufficient analysis been done to evaulate material stresses, dynamic response characteristics, slosh effects, or propellant expulsion efficienty of such a container.

Mr. Wuenscher was of the opinion that if general future probe design applications and specific project needs (as the toroidal propellant container system for the MSSR) justify a small tank fabrication and test development program, such a program would effectively compliment a large toroidal tank program presently being undertaken at MSFC.

Generally, the authors see various applications for toroidal tank design and suggest that a comprehensive fabrication program be undertaken to cover both large and small classes of tankage. Concurrent investigations of related problems such as propellant compatibility, material selection, expulsion techniques, stress analysis, and slosh effects should be incorporated to compliment the manufacturing methods study.

While such a toroidal tank development program is clearly worthwhile, it is the authors' belief that cryogenic tankage development and fabrication is a higher priority problem and should not be compromised.

Mr. Wuenscher has suggested further discussions to define and assess specific applications and requirements if such a program is justifiable and deemed worthy of the undertaking.

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Attachment:
  Figure 1
  Reference

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(see next page)

STRUCTURAL CONCEPT TOROIDAL TANK ASCENT VEHICLE

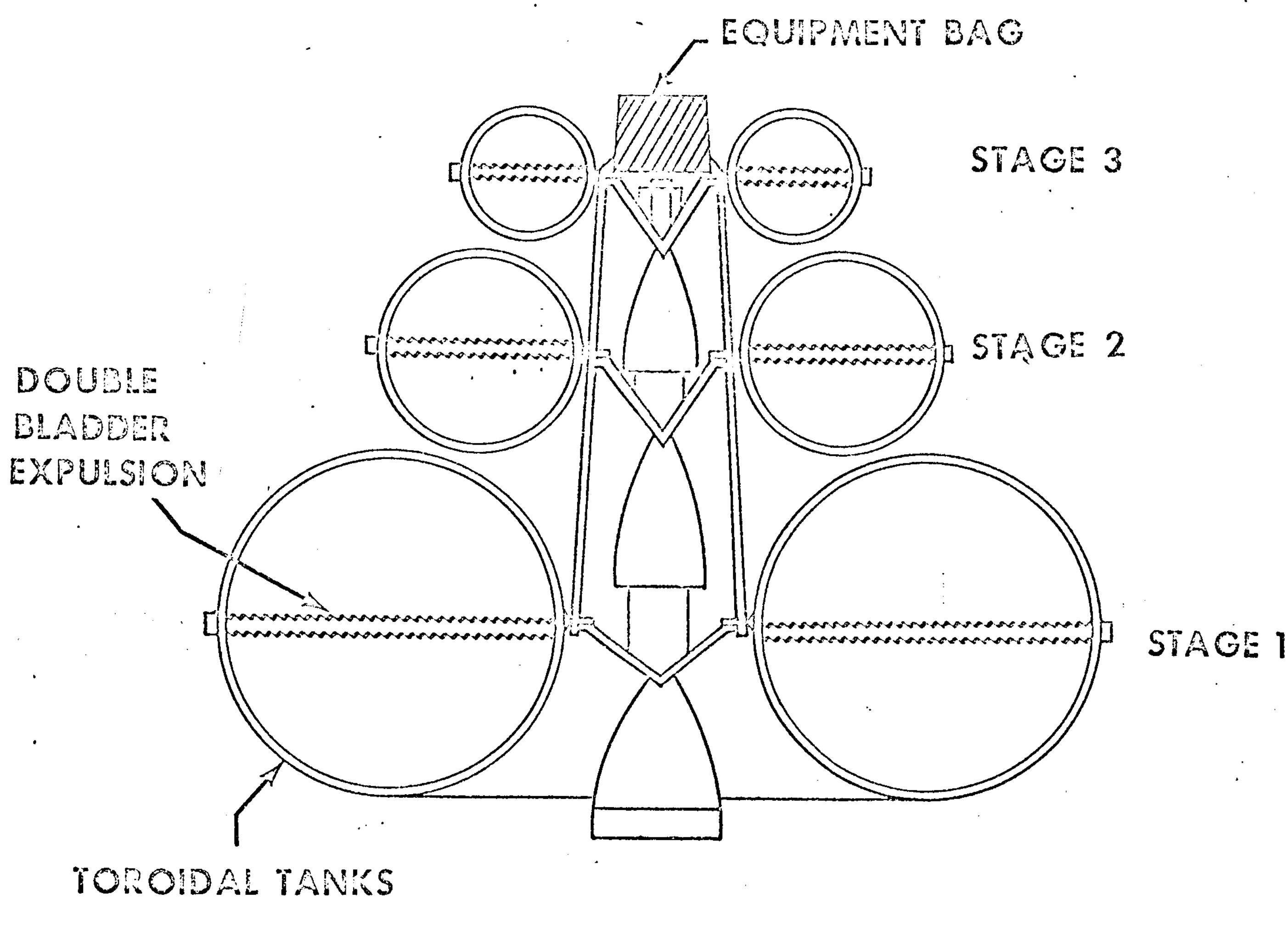

FIGURE 1

REFERENCES

1. Macchia, D., Dkeer, M. H., and Wong, J., "Conceptual Design of Structural and Propulsion Systems for an MSSR Rendezvous Vehicle," Bellcomm Memorandum for File, August 5, 1966.